Review

The tinySA spectrum analyser

Introduction

The tinySA spectrum analyser is a remarkable little device that provides spectrum analysis from 100kHz to 990MHz in two ranges. As if that wasn't enough, it also includes a signal generator for a similar frequency range. The tinySA has its origins in the NanoVNA project, which explains the look and presentation of the package. Author Erik Kaashoek started the tinySA as a fork of the NanoVNA project and has been assisted in the development by the NanoVNA-H author, Hugen. The resulting tinySA's compact size and retail price of about £70 make it an interesting proposition.

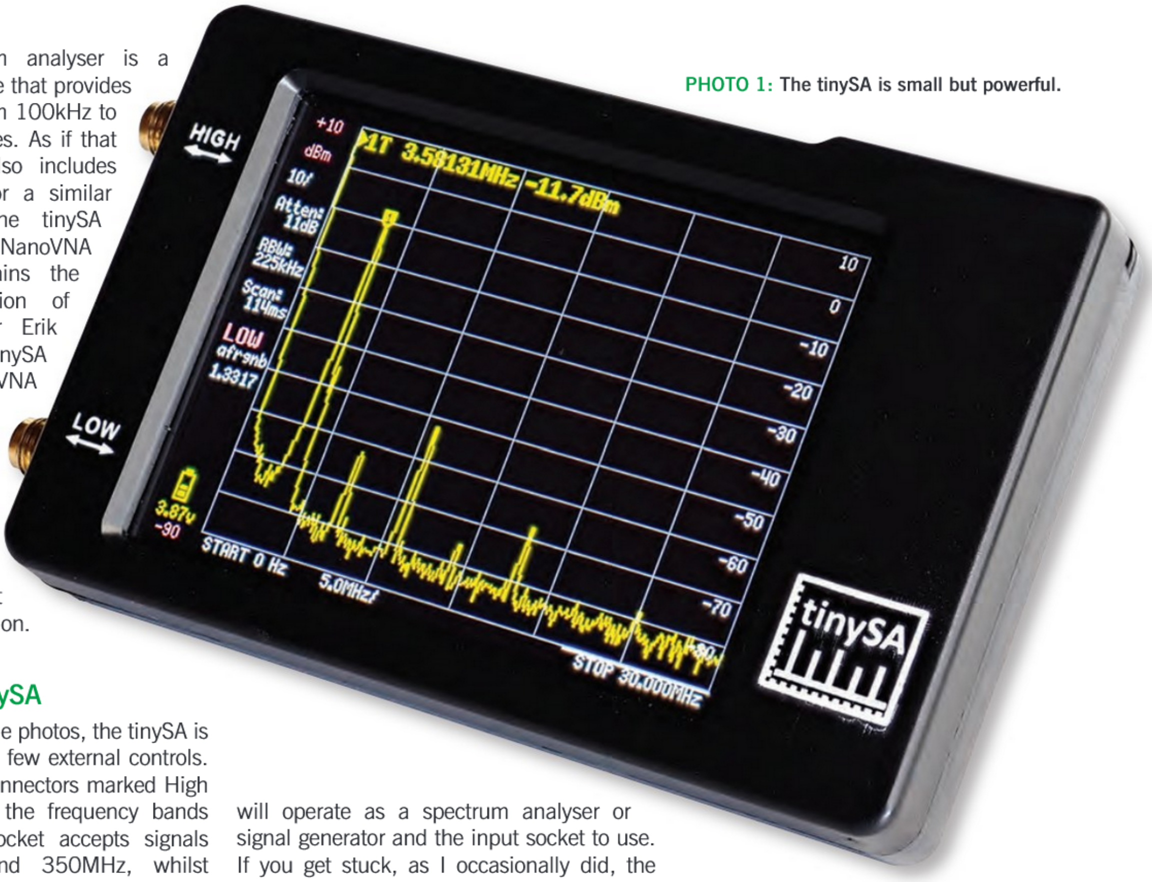

PHOTO 1: The tinySA is small but powerful.

Navigating the tinySA

As you can see from the photos, the tinySA is very compact and has few external controls. There are two SMA connectors marked High and Low, relating to the frequency bands covered. The Low socket accepts signals between 100kHz and 350MHz, whilst the High socket operates from 240MHz to 960MHz. The top panel has a slide switch for power and a combined rocker and press switch that can be used to navigate the tinySA menus or to steer the measurement markers. There is also a USB-C socket used to charge the internal battery, load any replacement firmware, and communicate with a computer. The main screen is touch-sensitive and this is the primary way to access and navigate the tinySA.

Those familiar with the NanoVNA will see that the tinySA uses a similar menu style. Although you can use your finger to navigate, this is not the best technique with such a small screen. The supplied guitar plectrum works quite well, but I found that a dedicated touch screen stylus gives the best results. To access the main menu, I simply tapped the screen. There are many options available, but for most, the starting point is to set the mode and frequency range. Mode is the last item on the menu but it's the one you need to use most as it determines whether the tinySA will operate as a spectrum analyser or signal generator and the input socket to use. If you get stuck, as I occasionally did, the first step is to return to the Mode menu and make sure it's correctly set. When selecting the frequency, I had two options: either set the start and stop frequency or the centre frequency and span. Frequencies are entered using an on-screen keyboard, which was simple to use, but you must ensure each

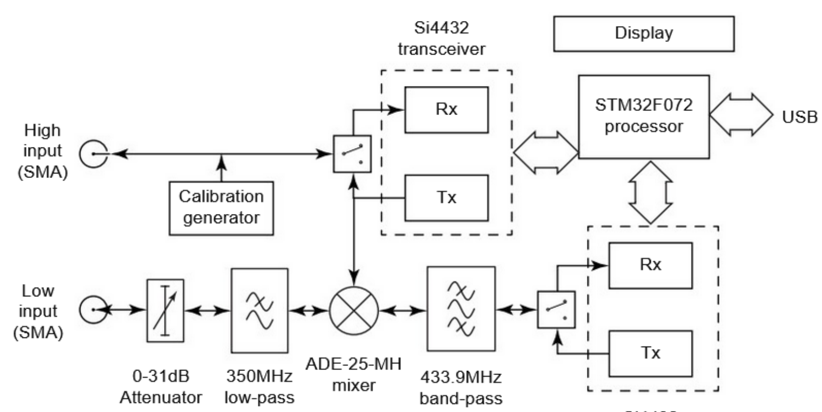

FIGURE 1: Simplified block diagram of the tinySA.

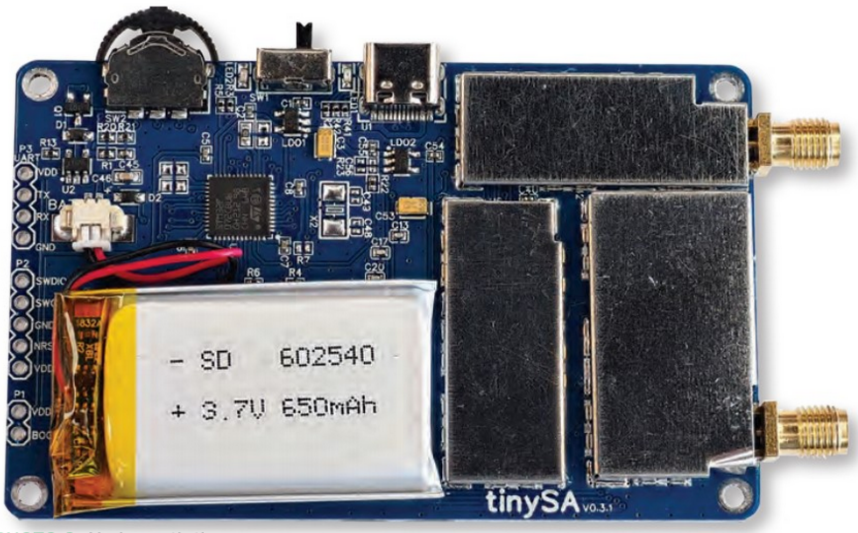

PHOTO 2: Underneath the covers.

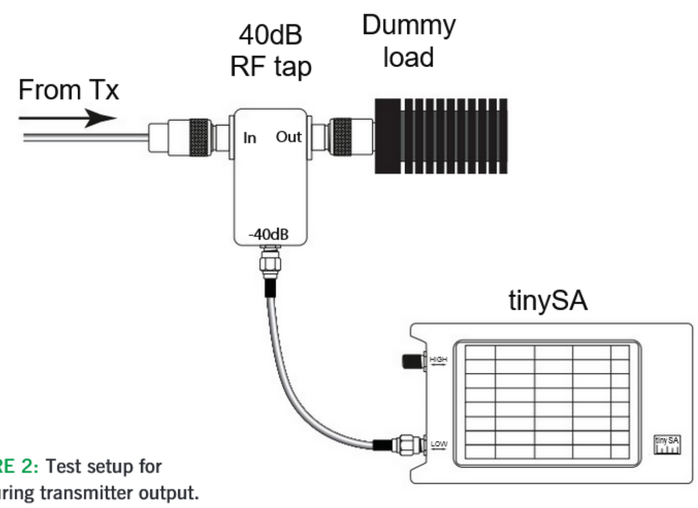

FIGURE 2: Test setup for measuring transmitter output.

digit registers before moving on. Once the frequencies are set, the spectrum analyser runs a continuous sweep, so the results are available immediately.

Whilst observing the spectrum is helpful, we also need to be able to make precise measurements. This is where markers come into their own – and there are plenty of them. You can have up to 3 simple markers, but the tinySA has a good selection of smart markers that will track, search minimum and maximum values, and search left and right of the centre point. There was also a helpful reset button to return all markers to their default setting. The reset was particularly helpful for restoring the markers after a measurement session. The tinySA has five programmable memories available to streamline everyday use, each of which can hold a complete configuration set. The first of these is called during power-up so is an excellent place to store your most commonly used configuration. This is a great time saver as your most common setup will be available whenever you cycle the power.

A look inside

The tinySA is based on a conventional heterodyne swept spectrum analyser design and makes ingenious use of transceiver chips designed for the ISM (Industrial, Scientific and Medical) bands. This approach dramatically reduces the component count and cost. The block diagram in **Figure 1** shows a simplified view of the tinySA. I'll run through the operation, beginning with the 0.1-350MHz Low range. Signals applied to the Low SMA connector are routed via a Periguine PE4302 programmable attenuator that provides up to 31dB of attenuation in 1dB steps. Next is a 350MHz low-pass, anti-aliasing filter, ahead of the Mini-Circuits ADE-25-MH mixer. This mixer provides up-conversion to a first IF of 433.9MHz, where a bandpass filter removes unwanted signals before passing to the first Si4432 ISM transceiver chip. The Si4432 receive section provides IF down conversion to the 870kHz final IF and includes selectable bandwidth filters (3kHz to 600kHz) to control the analyser's resolution bandwidth. Conveniently, the Si4432 also includes a 120dB linear dynamic range power detector in the receive chain. Although typically used for RSSI (Received Signal Strength Indicator), in this case, it measures our test signal. This power detector output feeds a microcontroller for final processing and display.

The High input uses a second Si4432 transceiver chip via a programmable RF switch. This chip has a frequency range of 240-930MHz and converts the incoming signal to the 870kHz final IF with the same 3kHz to 600kHz filtering options and power detector as the Low band. The transmit section of this chip also provides the local oscillator signal for ADE-25-MH first IF mixer when using the Low band.

Pulling all the information together and driving the display is the STM32F072 microcontroller. This versatile 48MHz microcontroller is bristling with communication interfaces including USB-2 for the computer link. The STM32 series of microcontrollers have proven very popular for small volume projects because they are well established, powerful and cheap (just under £3 each for 100+). Another attractive feature is the ROM based boot code. When uploading new firmware to the controller, the boot code puts the processor into the correct state to receive new firmware. In some processors, it is possible to destroy the boot code by loading the wrong firmware, thus making the device unusable ('bricked'!) However, the STM32's use of ROM protected boot code makes it close to impossible to 'brick' the processor, even if you load entirely the wrong firmware.

In addition to its operation as a spectrum analyser, the tinySA is also a signal generator. It has a sinewave output available from the Low socket that covers the range 100kHz to 350MHz with an output level that can be set between –7dBm and –76dBm. The High output provides a 240MHz to 960MHz square wave with a level adjustment range of +9dBm to –38dBm. It's worth noting that these signal generators cannot be used as a tracking generator.

Finally, the tinySA includes a useful 30MHz TCXO (Temperature Compensated Crystal Oscillator) that provides a squarewave

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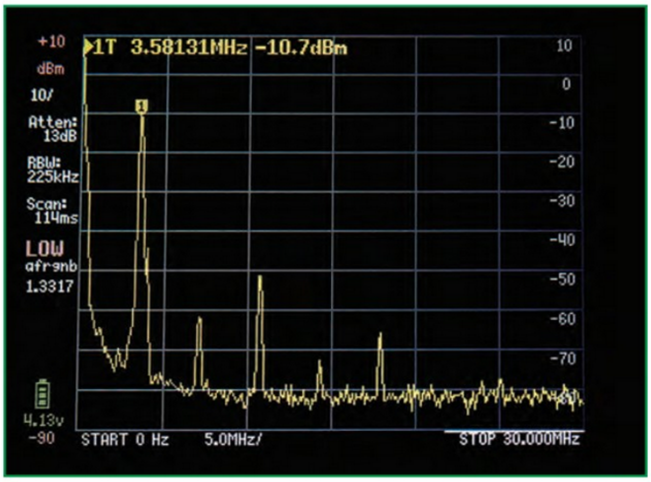

FIGURE 3: 50kHz to 30MHz transmitter spectrum.

calibration signal. This has switchable dividers to give 30, 15, 10, 4, 3, 2 and 1MHz calibration signals.

Accuracy

To make practical use of any test equipment, you need to be confident in the measurement accuracy. To check the tinySA, I applied a signal source of known quality set to 0dBm output and applied this to the tinySA via a HP 8496A attenuator (0-110dB). I then increased the attenuation in 10dB steps and recorded the level reported by a peak marker on the tinySA. The test frequencies used were 500kHz, 10.15MHz, 50MHz, 145MHz and 432MHz. At 500kHz the reported levels were within 1.5dB of the correct value and improved to within 1dB for all the other test frequencies. With the RBW (resolution bandwidth) set to Auto, the minimum usable input level was -90dBm. The accuracy was surprisingly good, especially considering the size and cost of the tinySA.

The calibration output could be set to 1MHz, 2MHz, 3MHz, 4MHz, 10MHz, 15MHz or 30MHz with a nominal output of –25dBm. On the review model, the output was just over 2dB high between 1MHz and 4MHz, then dropped to 1.1dB low at 30MHz.

I also checked the accuracy of the Low signal generator and the review model output level was between 3.5 and 4.5dB below the indicated output level. However, the attenuator tracking was good so, when the stated level was reduced by 10dB, the signal level also dropped by 10dB ±0.5dB. Not surprisingly, the High signal generator performance had a few problems. From +9 to 0dBm the output level was within 1dB of the indicated value. However, this deteriorated at lower levels and, by the minimum setting of –38dBm, the output was 7dB high. I also discovered a firmware bug where changing from –10dBm to –20dBm only reduced the output level by 2dB. I've reported this so it's likely to be fixed in a future firmware update. If you have an accurate signal generator or scope, you can use the tinySA's Expert menu to calibrate-out the errors.

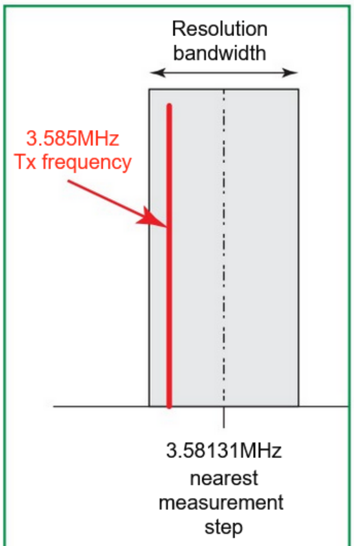

FIGURE 4: Illustration explaining the frequency step error.

Using the tinySA

While the theory is fine, there's nothing quite like taking real measurements to see how the tinySA fares. In addition to the tinySA itself, the smart presentation box includes a couple of short SMA-SMA patch cables and a telescopic antenna that could be handy for tracking down QRM sources.

The first candidate for testing was a low power HF transmitter I've been working on that has a less than ideal output spectrum. Before starting any measurements, I used the tinySA's level calibration and self-test facility. This can be found in the Config menu and is a quick and helpful check that all is well.

For the transmitter test, I connected the Tx ouput to a dummy load via a calibrated 40dB RF tap, whilst the tap output went to the tinySA Low input, as shown in **Figure 2**. I keyed the transceiver on 3.585MHz with the output set to approximately 1 watt. As I wanted to see the signal's harmonic content, I set the sweep range to 50kHz to 30MHz. I've shown the resulting plot in **Figure 3**, where you can clearly see the strong harmonic content. You may notice that the indicated frequency

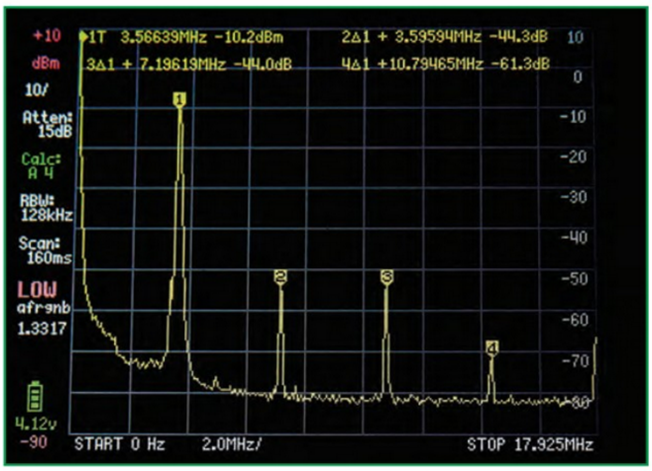

FIGURE 5: Automated harmonic measurement with the tinySA.

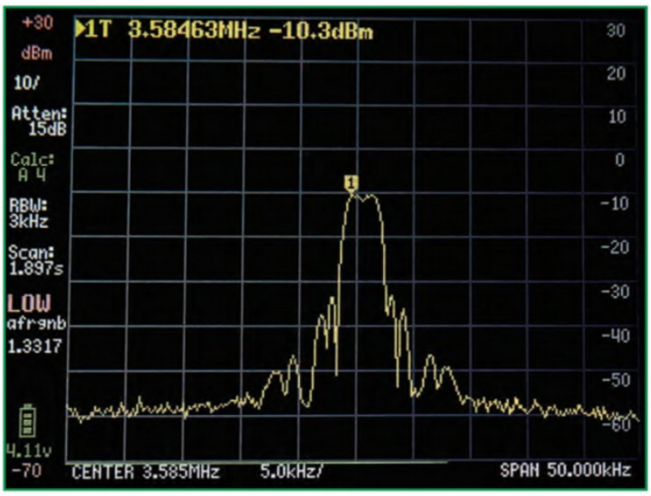

FIGURE 6: 50kHz wide sweep showing the flat top due to a wide RBW.

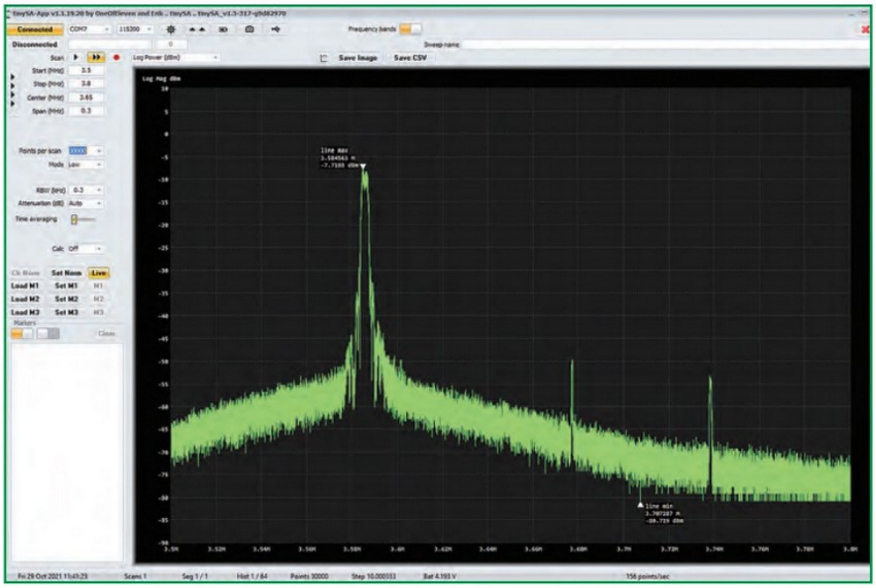

FIGURE 7: Detailed, 30,000 point sweep using tinySA software on a PC.

of the carrier is 3.58131MHz and not the 3.585MHz that was being sent. This confusing reading occurs because, like many spectrum analysers, the tinySA tunes in discrete steps with 290 steps per scan. With the range set to 50kHz to 30MHz, the steps are spaced just over 103kHz apart (30MHz/290). In this case, the 3.58131MHz reading represents the nearest step to the actual transmit frequency. If you take a close look at the display, you will also note that the resolution bandwidth is set to 225kHz. I've illustrated the effect in **Figure 4**. With this display, I could use the rocker control on the top panel to steer the marker to each peak to read off the frequencies and levels. However, the Measure menu of the tinySA has a harmonic option that will identify and measure the harmonics on the entered fundamental. I've shown the output in **Figure 5**. Here you can see that it's identified the fundamental, plus the 2nd, 3rd and 4th harmonics.

What's more, it's conveniently quoted the levels with reference to the carrier, which is very helpful. In addition to harmonics, the tinySA can directly measure 3rd-order intercept (OIP3), phase noise, signal to noise ratio (SNR), 3dB bandwidth, modulation depth, total harmonic distortion (THD), channel power and linearity.

To take a closer look at the transmitter carrier, I centred the sweep on 3.585MHz and set the sweep span to 50kHz; you can see the result in **Figure 6**. With the sweep span restricted to 50kHz there is a measurement step approximately every 170Hz (50,000/290). However, you will note that the sweep has a flat top instead of the expected narrow peak. This is due to the tinySA's minimum resolution bandwidth of 3kHz. With 170Hz steps and a 3kHz bandwidth, the carrier will be equally received by several consecutive measurements steps, hence the flat top.

Computer control

Whilst the 2.8" screen makes for a very compact unit, many will want to hook the tinySA to their computer for a larger display. The tinySA supports this through the USB-C connector on the top panel. For Windows users, the free tinySA-App is the one to go for. In addition to providing a larger spectrum view, this software lets you increase the number of measurement points to 30,000 (!) and use lower resolution bandwidths (down to 300Hz). **Figure 7** shows a high resolution scan of the test signal I used earlier. As you can see, it shows much more detail. However, as with all spectrum analysers, increasing the number of measurement points and narrowing the resolution bandwidth increases the sweep time considerably. In this example, each sweep took 3¼ minutes to complete. Those with Linux or Mac computers can download the Python program, tinySA-Saver. While this also displays data from the tinySA, it's confusing because it still includes the NanoVNA functionality, which doesn't work with the tinySA.

Summary

There is no doubt that the tinySA is an ingenious and surprisingly accurate device with myriad uses around the shack. The design has a few limitations but, in practice, these can often be worked around. The tinySA is ideal for checking the quality of your transmissions, tracking down QRM and helping get the most out of homebrew projects. Online support for the tinySA is excellent and there's a helpful WiKi available at https://tinysa.org/wiki

The tinySA is available from Mirfield Electronics (mirfield-electronics.co.uk) and costs £69.95 plus £5 postage. My thanks to Mirfield Electronics for the loan of the review model.

Specification summary.

Spectrum analyser	
Display	320 x 240 pixels, 2.8" diagonal, resistive touch control
Input ranges	Low input: 100kHz to 350MHz, High input: 240MHz to 960MHz
Input attenuator	0-31dB in 1dB steps (low input only)
Maximum input	+10dBm
Optimum input	-25dBm and below
Power detector	Resolution 0.5dB, accuracy ±1dB
Lowest discernable signal	Low: -102dBm (30kHz RBW) High: -115dBm (30kHz RBW)
Spur free dynamic range	Low: 70dB (30kHz RBW), High: 50dB(30kHz RBW)
Measurement points	51, 101, 145 or 290
Scanning speed	1000 points/second
Signal generator	
Output frequency range	100kHz-350MHz (low), 240MHz-960MHz (high)
Output type	Sine wave with harmonics <40dBC (low), square wave (high)
Level accuracy	±2dB (low), not specified for high band
Frequency resolution	156Hz below 47MHz and 312Hz above 47MHz (low); 156Hz below 480MHz and 312Hz above 480MHz (high)
Modulation	AM, narrow FM and wide FM (low), narrow FM and wide FM (high)
Reference generator	
Output	Square wave at -25dBm
Frequency	1MHz, 2MHz, 4MHz, 10MHz, 15MHz or 30MHz
Battery	
At least 2 hours operation, with charging via USB-C port	